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Mango Waste (Peel and Kernel) Enhances Food Dietary Fiber and Antioxidant Properties

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Biscuits are a global snack due to their convenience, variety, and durability. Biscuits with nutritious ingredients are in demand as customers become more health conscious. This change led to interest about utilizing agricultural by-products to enhance the nutritional value of widely consumed foods. Mango (*Mangifera indica* L.), a frequently cultivated tropical fruit, produces vital by-products during its processing, mainly comprising peels and kernels. The by-products, comprising around 35–60% of the mango fruit's weight, are high in bioactive compounds including dietary fiber, polyphenols, carotenoids, and essential fatty acids. Mango peels and kernels, even with their nutritional potential, frequently neglected, resulting in rising environmental waste. This study examines how mango peels and kernels can boost biscuits' nutritional fiber and antioxidant content. Researchers synthesize mango by-product nutritional and functional benefits and extraction and processing technologies. The study also examines mango by-products' sensory and economic effects on biscuits. High fiber and antioxidant content in mango peel powder improve digestion and reduce oxidative stress. With its beneficial fats and polyphenols, mango kernel powder adds nutrition. Health-conscious consumers may choose biscuits with 5–15% mango by-products since they retain or increase flavor, texture, and color. By-products from mangoes reduce food waste and promote a circular economy. Commercial application requires optimizing processing procedures, product quality consistency, and clinical trials to validate health claims. According to this analysis, mango by-products can enable creative and sustainable food production and meet customer demand for health-focused goods.

Keywords: Biscuits, mango waste, kernels, peels, sustainability, nutrients, antioxidant properties, dietary fibre.

INTRODUCTION

Biscuits count among the most common baked goods worldwide, appreciated for their utility, extended shelf life, and diverse taste options. Historically, biscuits were used as a practical food for long journeys for their durability, and they remain popular among various age groups and demographics (Ghnimi *et al.*, 2023; Hussain *et al.*, 2023). However, regular biscuit recipes frequently contain a high amount of refined carbohydrates, fats, and sugars, leading to enhanced energy density while providing limited nutritional advantages (Gupta and Kaur, 2023; Mahmood *et al.*, 2023). The growing consumer focus on health and wellness, the food industry is actively looking into ways to improve the nutritional quality of biscuits through the addition of functional ingredients that offer health benefits (Yu and Watson, 2024). A notable source of functional ingredients can be found in agricultural by-products, especially those resulting from fruit processing (Albaayit, 2021). Mango (*Mangifera indica* L.) has been recognised for its high vitamin and antioxidant content, making it one of the most widely cultivated and consumed tropical fruits globally (Alshammaa, 2016). Annual global mango production is >50 million tones. Major producers of mango include India, Bangladesh, China, Mexico, Pakistan, Indonesia, Brazil, Thailand, and the Philippines, and it is shipped worldwide (Ullah *et al.*, 2024). But the processing of mangoes leads to considerable waste, mainly made up of peels and kernels, which represent 35-60%

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of the fruit's weight, varying with the variety and methods used (García-Mahecha *et al.*, 2023). Management of this by-product addresses environmental concerns and emphasizes a missed chance to use these materials' nutrients (Wall-Medrano *et al.*, 2020). Studies identified dietary fiber, carotenoids, polyphenols, essential fatty acids, and proteins in mango peels and kernels (Lebaka *et al.*, 2021). Chemicals offer several benefits. Mango peels include dietary fiber and polyphenols, promoting digestive health, blood sugar regulation, and cholesterol reduction (Tariq *et al.*, 2023). Essential fatty acids and phenolic compounds in mango kernels prevent oxidative stress and benefit the heart (Mwaurah *et al.*, 2020). Biscuits made with mango by-products may include more fiber and antioxidants (Ashoush and Gadallah, 2011). Biscuits with mango peel and kernel powders reduce food waste and promote a circular economy. Making food from byproducts is ecologically good and economically rewarding (Osorio *et al.*, 2021). According to different research, reutilization mango by-products can satisfy customer demand for eco-friendly and health-promoting products (Wall-Medrano *et al.*, 2020).

Mango by-products integration (5-15%) in biscuit formulations strengthens nutritional content without affecting taste, texture, or appearance, enhancing consumer (Puscas *et al.*, 2023).

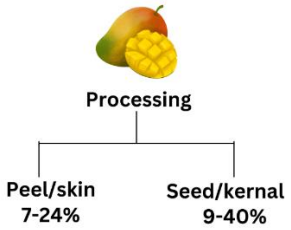

Figure 1. Mango waste production after processing (Aggarwal *et al.*, 2017)

Nutritional and Functional Properties of Mango Peel and Kernel

***Nutritional composition*:** The mango peel and kernel, notably, contain various bioactive components, therefore being essential for food fortification. Mango peels have 45-50% of their dry weight in nutritional fiber. Fiber, particularly soluble and insoluble fractions, helps digestive health, lowers blood sugar, and decreases cholesterol levels (Wall-Medrano *et al.*, 2020). Mango peel is abundant in fibers and polyphenols such as flavonoids, tannins, and phenolic acids (Lebaka *et al.*, 2021). Antioxidant substances like these could lower chronic disease risk by eliminating free radicals (Arshad *et al.*, 2021). Beta-carotene and lutein in mango peel protect against macular degeneration due to age and enhance eye health (Okur, 2019). Yet mango kernels comprise lipids, proteins, and phenolics. The unsaturated fatty acids were present in mango kernel which helps to reduce the (low-density lipoprotein cholesterol) LDL and also improve the cardiovascular health (O'Neil *et al.*, 2013). It also had two acids (gallic and ellagic) which are anti-oxidents and fight against cancer items (Velderrain-Rodríguez *et al.*, 2018; Albaayit, 2020). The proteins present in it helps in muscle repair and maintenance (Masibo and He, 2009). These qualities make it nutritious ingredient for biscuits.

***Functional Properties*:** It has bioactive effects that boost health such as antioxidants and helps to reduced oxidative stress, which may result in cardiovascular disease, diabetes, and cancer, can be controlled by antioxidants (Albaayit *et al.*, 2021). *In vitro*, mango peel polyphenols lower oxidative stress, suggesting they may enhance health when ingested frequently (Tariq *et al.*, 2023).

Mango byproducts had anti-inflammatory and antioxidants properties. Chronic inflammation increases the risk of arthritis, cardiovascular disease, and several malignancies (Albaayit *et al.*, 2022). Mangiferin, found in mango peel, reduces inflammation by blocking pro-inflammatory cytokines (Kim *et al.*, 2021). Mango kernel comprises gallic and ellagic acids, which may fight cancer. These chemicals can trigger cancer cell apoptosis and minimize tumor development, suggesting mango kernel could stop cancer (Shaban *et al.*, 2023). Benefits of mango by products include cardiovascular health. Mango kernel unsaturated fatty acids decrease LDL cholesterol and mango peel fiber regulates blood pressure and sugar (Kim *et al.*, 2021). Mango peel and kernel contain bioactive substances that boost cardiovascular health. Unlike pomegranate seed powder, grape pomace, and banana peel flour, mango by-products have independent fibers, antioxidants, and important fatty acids. Banana peel powder has fiber and resistant starch, whereas mango peel has more polyphenols and carotenoids, making it a better antioxidant (Bello-Pérez and Agama-Acevedo, 2019). Grape pomace has polyphenolics but not mango kernel's heart-healthy fatty acids (Teshome *et al.*, 2023). Mango by-products can be used to improve biscuits and other foods, aligning with customer preferences for natural and nutrient-rich foods (Iqbal *et al.*, 2021).

Extraction and Processing Techniques for Mango By-products

Extraction and preservation boost beneficial chemical production and activity and retain nutritional value (Chemat *et al.*, 2017). Mango peel and kernel bioactives must be extracted and processed for food products (Mwaurah *et al.*, 2020).

***Extraction methods*:** Many methods have been tried to extract bioactive components from mango peels and kernels (Asif *et al.*, 2016). Based on target substances and use, each approach has benefits.

Optimization methods

Optimization has been studied to boost extraction efficiency. To enhance yield and preserve bioactive compounds, these methods manage extraction parameters including temperature, solvent concentration, and frequency.

Table 1. Extraction techniques

Extraction technique	Principle	Compounds analyzed	Cost effectiveness	Use in mango by-product analysis	References
Microwave-Assisted Extraction (MAE)	Utilizes microwave energy to rapidly heat solvents, can be use in cell wall rupture and facilitating the release of bioactive compounds.	Polyphenols, antioxidants	High initial cost, but solvent savings make it cost-effective in large-scale applications.	Effective for large-scale extraction of antioxidants from mango peel, which can be used in functional food formulations.	(Peñas *et al.*, 2023)
Ultrasound-Assisted Extraction (UAE)	Uses ultrasonic waves to create cavitation bubbles that disrupt cell walls and enable the release of bioactives.	Flavonoids, tannins, carotenoids	Moderate cost, generally cost-effective due to energy efficiency and lower temperatures.	Suitable for extracting temperature-sensitive bioactives, such as antioxidants and carotenoids, from mango kernel and peel.	(Cravotto and Binello, 2016)
Aqueous and Solvent-Based Extractions	Relies on either water or solvents to dissolve and extract specific compounds based on their solubility and affinity.	Dietary fiber, phenolic compounds, lipids	Low cost (aqueous), moderate to high cost (solvent-based) depending on solvent used.	Commonly used for fiber extraction from mango peels and phenolic compound extraction from both peel and kernel.	(Panzella *et al.*, 2020)

***Artificial Neural Networks (ANN)*:** Learning from data, ANN models replicate non-linear correlations and interactions between variables to accurately predict extraction results. ANN improved mango by-product flavonoids and phenolic extraction parameters for efficiency and repeatability (Ramirez-Brewer *et al*., 2024). This method is useful in food engineering since plant material and target components impact extraction parameters.

***Response Surface Methodology (RSM)*:** It's a statistical approach to optimize mango peel bioactive chemical extraction conditions for phenolic content and antioxidant activity (Ramírez-Brewer *et al*., 2024). RSM improves mango by-product ultrasound-assisted extraction (UAE) and microwave-assisted extraction (MAE) (Sarker *et al*., 2024).

***Preservation and processing*:**To sustain nutritional and functional properties during storage and use in savoury products, bioactive components must be conserved after extraction.

***Oven-drying*:**Its cost-effective but lowers antioxidant activity due to heat (Kuçuk *et al*., 2024).

***Freeze drying*:** Low temperature in freeze-drying maintains nutritional quality by reducing degradation of vital elements like carotenoids and phenolics (Minuye *et al*., 2024).

***Spray drying*:** Nevertheless, spray-drying is cheaper and suited for industrial production but could result in volatile bioactives (Homayoonfal *et al*., 2024).

Processing techniques greatly impact nutritional retention in mango by-products. Freeze-drying protects the majority of phenolic compounds and antioxidants, followed by spray-drying and oven-drying (Kumar and Suhag, 2024). Efficient preservation protects mango by-products' health benefits and makes them practical as functional ingredients in biscuits (Hasan *et al*., 2024a).

***Application of Mango By-products in Biscuits*:**

Incorporating mango and kernel peels into biscuits can increase their nutritional value and appeal. This section highlights mango-fortified biscuits' nutritional value, functional and sensory properties, comparative benefits over other fruit byproducts, and acceptance by consumers.

***Functional and sensory properties*:** The inclusion of mango peel and kernel powders affects the sensory qualities of biscuits, including texture, color, and flavor. Research indicates that moderate amounts of mango by-products (5–15%) can improve sensory properties, enhancing appeal without compromising consumer acceptance such as mango peel powder has mild fruity flavour with golden yellow colour (Marcal and Pintado, 2021). Higher fiber contents make the eating item denser and less fragile. While, small amount of fibers make it crispy and large amount of fiber make it harder because fibers binds with water. For balanced nutritional benefits and good texture, 10% is recommended (Shabeer, 2016). Mango kernel powder adds a delicate nutty flavor and healthy fats to the flavor profile and mouthfeel at moderate doses (Guzman *et al*., 2015).

***Nutritional enhancement*:** Mango peel and kernel powder boosts biscuits' dietary fiber and antioxidant content, meeting consumer demand for healthy snacking. Dietary fiber in mango peel promotes digestion, glycemic management, and satiation. Kaur, B. *et al*. (2023) found that mango peel powder biscuits have 20% more dietary fiber than regular biscuits. Fiber enhances digestive health and helps meet daily fiber needs (Anderson *et al*., 2009). Mango by-products contain antioxidants such polyphenols and carotenoids, which minimize oxidative stress and may lower chronic disease risk. Studies show that mango peel powder-enriched cookies have more antioxidant capacity due to free radical-scavenging phenolic components such gallic acid and mangiferin (Masibo and He, 2009). This enhancement makes mango by-product-enriched biscuits a suitable choice for those taking functional foods with added health benefits.

***Comparative analysis with other by-products*:** Banana peel powder, even though rich in dietary fiber, can introduce an

Table 2. Possible Environment and Economical benefits.

Parameter	Impact	Details	References
Sustainability	Reduction in food waste	Mango peel and kernel waste, constituting up to larger part of the fruit, can be diverted from landfills, reuse valuable nutrients and reducing pollution.	(Pedro *et al.*, 2024)
	Lower environmental impact	Life-cycle assessments reveal that utilizing mango by-products in food products reduces greenhouse gas emissions and water usage, compared to traditional disposal methods.	(Di Fraia *et al.*, 2024)
	Biodiversity conservation	Reduced reliance on synthetic additives and preservatives decreases the need for additional agricultural inputs, promoting biodiversity conservation.	(Michel *et al.*, 2024)
Economic feasibility	Cost savings	Incorporating mango peel and kernel can replace synthetic ingredients, providing natural fiber, antioxidants, and bioactive compounds at a lower cost.	(Gupta *et al.*, 2022)
	Revenue generation	The valorization of mango waste allows mango processors to generate additional income and avoid disposal costs.	(Ansari *et al.*, 2024)
	Cost-benefit advantage	Utilization mango by-products as a partial substitute for wheat flour not only lowers ingredient costs but also supports a premium pricing strategy due to enhanced health benefits such as fiber and antioxidants.	(Das *et al.*, 2019)
Circular economy	Resource efficiency	Transforming mango peel and kernel into food ingredients aligns with circular economy principles, reducing waste and utilizing resources efficiently.	(Kumar Gupta *et al.*, 2024)
	Environmental impact mitigation	This approach reduces reliance on landfills and decreases greenhouse gas emissions from waste decomposition, meeting consumer demand for sustainable products.	(Kaur, M. *et al.*, 2023)
	Expansion of applications	Beyond biscuits, mango by-products have potential in other food products like energy bars and cereals, further supporting a circular food system.	(Rakesh and Mahendran, 2024)

acidic taste to biscuits, which limit its application to lower replacement proportions (Mitu, 2022) while, mango peel powder presents a more delicate flavor profile, enabling greater incorporation rates without adversely affecting the overall taste (Kalra and Tandon, 1995). Pomegranate seed powder is known for its antioxidant properties; nevertheless, it is free of the essential fatty acids present in mango kernel, which provide additional benefits for cardiovascular health (Jaglan *et al.*, 2022). Grape pomace, a by-product abundant in polyphenols, is often incorporated into baked goods; however, its brighter color and flavor might not be as readily supported as the milder taste of mango peel. Studies into these by-products demonstrate that mango peel offers a broad array of nutritional benefits, such as fiber, antioxidants, and carotenoids, positioning it as a flexible choice for enriching biscuits (Ahmed, 2015).

***Environmental and Economic Feasibility*:** The use of mango by-products in biscuit provides considerable environmental and economic benefits.

***Challenges and Future Directions*:** Using mango in biscuits presented technical hurdles and significant potential benefits. Expanding microwave- and ultrasound-assisted extraction technologies from lab studies to industrial applications is expensive and needs particular tools, making it difficult for small and medium-sized firms. The flexibility of mango by-products makes uniformity challenging, and balancing health benefits and tastes in biscuits requires comprehensive testing to ensure consumer approval. The long-term health impacts of mango by-products and how different cultures view them are still unknown. With natural fiber and antioxidants, mango by-products can boost snacks, cereals, and energy bars beyond biscuits. They can be used in biodegradable packaging and cosmetics due to their antibacterial and skin-enhancing qualities. Mango kernel can be utilized in animal feed, and mango peel sugars can be used to make bioethanol, which will assist create renewable energy sources. These applications promote sustainability and increase mango by-product value across industries in line with circular economy concepts.

***Conclusion*:** Biscuits made with mango peel and kernel is nutritious and useful. Mango waste increases fortified food's nutritional value and reduces food waste because to its high fiber, antioxidant, and bioactive content. They may improve digestive, cardiovascular, and oxidative stress health, meeting an increasing need for eco-friendly products. Mango waste is a cost-effective and diverse food ingredient that fits consumer demand for natural and functional meals. Large-scale extraction and processing technologies are difficult to perfect, thus more research on long-term health effects and customer acceptance is needed. As the business progresses toward sustainability and circular economy, mango waste materials' food fortification needs more research.

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REFERENCES

Aggarwal, P., A. Kaur and S. Bhise. 2017. Value-added processing and utilization of mango by-products. Handbook of mango fruit: Production, postharvest science, processing technology and nutrition. pp. 279-293.

Anderson, J.W., P. Baird, R.H. Davis, S. Ferreri, M. Knudtson, A. Koraym, V. Waters and C.L. Williams. 2009. Health benefits of dietary fiber. Nutrition Reviews 67:188-205.

Ansari, S.A., T. Kumar, R. Sawarkar, M. Gobade, D. Khan and L. Singh. 2024. Valorization of food waste: A comprehensive review of individual technologies for producing bio-based products. Journal of Environmental Management 364:121439.

Alshammaa, D. 2016. Preliminary screening and phytochemical profile of Mangifera indica leave's extracts, cultivated in Iraq. Int. J. Curr. Microbiol. Appl. Sci, 5:163-173.

Albaayit, S.F.A., R. Maharjan, R. Abdullah, M.H. Mohd Noor. 2022. Evaluation of anti-methicillin-resistant Staphylococcus aureus property of zerumbone. Journal of Applied Biomedicine, 20:15-21.

Albaayit, S.F.A. 2021. Evaluation of anti-methicillin resistant *Staphylococcus aureus* property of *Clausena excavata* leaves by using atomic force microscopy and flowcytometry techniques. Pakistan Journal of Agricultural Sciences 58:315-320.

Arshad, F., H. Umbreen, I. Aslam, A. Hameed, K. Aftab, W.H. Al-Qahtani, N. Aslam and R. Noreen. 2021. Therapeutic role of mango peels in management of dyslipidemia and oxidative stress in obese females. BioMed Research International 2021:3094571.

Ahmed, E.F. 2015. Antimicrobial and antibiofilm activity of mango seeds extract. Iraqi Journal of Science 56:3121-3129.

Ashoush, I. and M. Gadallah. 2011. Utilization of mango peels and seed kernels powders as sources of phytochemicals in biscuit. World Journal of Dairy & Food Sciences 6-35:42.

Albaayit, S.F.A., M.A Khan and R. Abdullah. 2021. Zerumbone induces growth inhibition of Burkitt's lymphoma cell line via apoptosis. Natural Volatiles and Essential Oils 8:56-63.

Asif, A., U. Farooq, K. Akram, Z. Hayat, A. Shafi, F. Sarfraz, M.A.I. Sidhu, H.-u. Rehman and S. Aftab. 2016. Therapeutic potentials of bioactive compounds from mango fruit wastes. Trends in Food Science & Technology 53:102-112.

Albaayit, S.F.A. 2020. *In vitro* evaluation of anticancer activity of Moringa peregrina seeds on breast cancer cells. The Eurasia Proceedings of Science Technology Engineering and Mathematics, 11:163-166.

Bello-Pérez, L.A. and E. Agama-Acevedo. 2019. Banana and mango flours. In: *Flour and breads and their fortification in health and disease prevention*: Elsevier, pp.153-164.

Chemat, F., N. Rombaut, A. Meullemiestre, M. Turk, S. Perino, A.-S. Fabiano-Tixier and M. Abert-Vian. 2017. Review of green food processing techniques: Preservation, transformation, and extraction. Innovative Food Science & Emerging Technologies 41:357-377.

Cravotto, G. and A. Binello. 2016. Low-frequency, high-power ultrasound-assisted food component extraction. In: *Innovative food processing technologies.* Elsevier, pp.3-29.

Das, P.C., M.J. Khan, M.S. Rahman, S. Majumder and M.N. Islam. 2019. Comparison of the physico-chemical and functional properties of mango kernel flour with wheat flour and development of mango kernel flour based composite cakes. NFS Journal 17:1-7.

Di Fraia, S., V. Godvin Sharmila, J.R. Banu and N. Massarotti. 2024. A comprehensive review on upcycling of food waste into value added products towards a circular economy: Holistic approaches and life cycle assessments. Trends in Food Science & Technology 143:104288.

García-Mahecha, M., H. Soto-Valdez, E. Carvajal-Millan, T.J. Madera-Santana, M.G. Lomelí-Ramírez and C. Colín-Chávez. 2023. Bioactive compounds in extracts from the agro-industrial waste of mango. Molecules 28:458.

Ghnimi, H., M. Ennouri, C. Chèné and R. Karoui. 2023. A review combining emerging techniques with classical ones for the determination of biscuit quality: Advantages and drawbacks. Critical Reviews in Food Science and Nutrition 63:5009-5032.

Gupta, A. and S. Kaur. 2023. Biscuits. In: *Cereal-based food products*: Springer, pp.53-72.

Gupta, A.K., P.S. Gurjar, K. Beer, A. Pongener, S.C. Ravi, S. Singh, A. Verma, A. Singh, M. Thakur, S. Tripathy and D.K. Verma. 2022. A review on valorization of different byproducts of mango (*Mangifera indica* L.) for functional food and human health. Food Bioscience 48:101783.

Guzman, I., M.H. Grace, G.G. Yousef, I. Raskin and M.A. Lila. 2015. Novel strategies for capturing health-protective mango phytochemicals in shelf stable food matrices. International Journal of Food Sciences and Nutrition 66:175-185.

Hasan, M.M., M.R. Islam, A.R. Haque, M.R. Kabir and S.K. Hasan. 2024a. Fortification of bread with mango peel and pulp as a source of bioactive compounds: A comparison with plain bread. Food Chemistry Advances 5:100783.

Homayoonfal, M., N. Malekjani, V. Baeghbali, E. Ansarifar, S. Hedayati and S.M. Jafari. 2024. Optimization of spray drying process parameters for the food bioactive ingredients. Critical Reviews in Food Science and Nutrition 64:5631-5671.

Hussain, A., T. Kausar, M.A. Majeed, J. Aslam, M. Imtiaz, H. Haroon, N. Abbas and A. Ali. 2023. Development of nutritional biscuits for children, rich in Fe and Zn, by incorporation of pumpkin (*Cucurbita maxima*) seeds powder; a healthy pharma food in current post covid 19 period. Pure and Applied Biology 12:392-403.

Iqbal, A., P. Schulz and S.S. Rizvi. 2021. Valorization of bioactive compounds in fruit pomace from agro-fruit industries: Present insights and future challenges. Food Bioscience 44:101384.

Jaglan, P., H.S. Buttar, O. Al-bawareed and S. Chibisov. 2022. Potential health benefits of selected fruits: Apples, blueberries, grapes, guavas, mangos, pomegranates, and tomatoes. In: *Functional foods and nutraceuticals in metabolic and non-communicable diseases*: Elsevier pp.359-370.

Kalra, S. and D. Tandon. 1995. Mango. In: *Handbook of fruit science and technology*: CRC Press, pp.139-186.

Kaur, B., P.S. Panesar, A.K. Anal and S. Chu-Ky. 2023. Recent trends in the management of mango by-products. Food Reviews International 39:4159-4179.

Kaur, M., A.K. Singh and A. Singh. 2023. Bioconversion of food industry waste to value added products: Current technological trends and prospects. Food Bioscience 55:102935.

Kim, H., M.J. Castellon-Chicas, S. Arbizu, S.T. Talcott, N.L. Drury, S. Smith and S.U. Mertens-Talcott. 2021. Mango (*Mangifera indica* L.) polyphenols: Anti-inflammatory intestinal microbial health benefits, and associated mechanisms of actions. Molecules 26:2732.

Kučuk, N., M. Primožič, P. Kotnik, Ž. Knez and M. Leitgeb. 2024. Mango peels as an industrial by-product: A sustainable source of compounds with antioxidant, enzymatic, and antimicrobial activity. Foods 13:553.

Kumar Gupta, R., E. Ae Ali, F. Abd El Gawad, V. Mecheal Daood, H. Sabry, S. Karunanithi and P. Prakash Srivastav. 2024. Valorization of fruits and vegetables waste byproducts for development of sustainable food packaging applications. Waste Management Bulletin 2:21-40.

Kumar, Y. and R. Suhag. 2024. Freeze drying of fruits and vegetables. Freeze Drying of Food Products: Fundamentals, Processes and Applications pp. 73-104.

Lebaka, V.R., Y.-J. Wee, W. Ye and M. Korivi. 2021. Nutritional composition and bioactive compounds in three different parts of mango fruit. International Journal of Environmental Research and Public Health 18:741.

Marcal, S. and M. Pintado. 2021. Mango peels as food ingredient/additive: Nutritional value, processing, safety and applications. Trends in Food Science & Technology 114:472-489.

Masibo, M. and Q. He. 2009. Mango bioactive compounds and related nutraceutical properties- a review. Food Reviews International 25:346-370.

Michel, M., A.L. Eldridge, C. Hartmann, P. Klassen, J. Ingram and G.W. Meijer. 2024. Benefits and challenges of food processing in the context of food systems, value chains and sustainable development goals. Trends in Food Science & Technology 153:104703.

Minuye, M., A. Yenasew and S. Belew. 2024. Effect of drying method on the nutritional and antioxidant properties of mango, avocado, and tomato. Journal of Horticultural Research 32:43-50.

Mitu, S.A. 2022. Development of functional food (biscuit) using banana peels, Chattogram Veterinary & Animal Sciences University.

Mwaurah, P.W., S. Kumar, N. Kumar, A. Panghal, A.K. Attkan, V.K. Singh and M.K. Garg. 2020. Physicochemical characteristics, bioactive compounds and industrial applications of mango kernel and its products: A review. Comprehensive Reviews in Food Science and Food Safety 19:2421-2446.

Mahmood, S., N. Omar, H. Sallehuddin, M.A. Albayaty, B.N. Mohd Yusof and Z. Zohari. 2023. Nutritional Status, Vitamin D and Lifestyle of Adults with and without Type 2 Diabetes in Baghdad, Iraq: A Comparative Cross-Sectional Study. IIUM Medical Journal Malaysia, 22(2)

O'Neil, C., T. Nicklas and V. Fulgoni. 2013. Mangoes are associated with better nutrient intake, diet quality, and levels of some cardiovascular risk factors: National health and nutrition examination survey. Journal of Nutrition and Food Science 3:229.

Okur, Ö.D. 2019. Lutein and zeaxanthin: Health-friendly nutrients. Karaelmas Fen ve Mühendislik Dergisi 9:56-61.

Osorio, L.L.D.R., E. Flórez-López and C.D. Grande-Tovar. 2021. The potential of selected agri-food loss and waste to contribute to a circular economy: Applications in the food, cosmetic and pharmaceutical industries. Molecules 26:515.

Panzella, L., F. Moccia, R. Nasti, S. Marzorati, L. Verotta and A. Napolitano. 2020. Bioactive phenolic compounds from agri-food wastes: An update on green and

sustainable extraction methodologies. Frontiers in Nutrition. 7:60.

Pedro, A.C., G.M. Maciel, N.P. Lima, N.F. Lima, I.S. Ribeiro, D.F. Pinheiro and C.W.I. Haminiuk. 2024. Valorization of bioactive compounds from juice industry waste: Applications, challenges, and future prospects. Trends in Food Science and Technology 152:104693.

Peñas, E., B. Hernandez-Ledesma and C. Martinez-Villaluenga. 2023. Microwave-assisted extraction of plant proteins. In: *Green protein processing technologies from plants: Novel extraction and purification methods for product development*: Springer, pp.211-236.

Puscas, A., A.E. Tanislav, R.A. Marc, V. Muresan and A. Muresan. 2023. Valorisation of mango peel and seed wastes in a biologically enriched biscuit assortment. Turkish Journal of Agriculture and Forestry 47:1174-1181.

Rakesh, B. and R. Mahendran. 2024. Upcycling of food waste and food loss – a sustainable approach in the food sector. Trends in Food Science & Technology 143:104274.

Ramírez-Brewer, D., S.E. Quintana and L.A. García-Zapateiro. 2024. Modeling and optimization of microwave-assisted extraction of total phenolics content from mango (*Mangifera indica*) peel using response surface methodology (RSM) and artificial neural networks (ANN). Food Chemistry: X 22:101420.

Sarker, M.S., M.M. Alam, C. Jiao, W. Shuqi, L. Xiaohui, N. Ali, L. Mallasiy and A.A. Alshehri. 2024. Maximizing polyphenol yield: Ultrasound-assisted extraction and antimicrobial potential of mango peel. Preparative Biochemistry & Biotechnology Vol. 1-10.

Shaban, N.Z., F.H. El-Rashidy, A.H. Adam, D.M. Beltagy, A.E. Ali, A.A. Abde-Alaziz and I.M. Talaat. 2023. Anticancer role of mango (*Mangifera indica* L.) peel and seed kernel extracts against 7, 12-dimethylbenz [a] anthracene-induced mammary carcinogenesis in female rats. Scientific Reports 13:7703.

Shabeer, M., M.T. Sultan, M. Abrar, M. Suffyan Saddique, M. Imran, M. Saad Hashmi and M. Sibt-e-Abbas. 2016. Utilization of defatted mango kernel in wheat-based cereals products: Nutritional and functional properties. International Journal of Fruit Science 16:444-460.

Tariq, A., A. Sahar, M. Usman, A. Sameen, M. Azhar, R. Tahir, R. Younas and M.I. Khan. 2023. Extraction of dietary fiber and polyphenols from mango peel and its therapeutic potential to improve gut health. Food Bioscience 53:102669.

Teshome, E., T.A. Teka, R. Nandasiri, J.R. Rout, D.V. Harouna, T. Astatkie and M.M. Urugo. 2023. Fruit by-products and their industrial applications for nutritional benefits and health promotion: A comprehensive review. Sustainability 15:7840.

Ullah, M.A., A. Khanal, P. Joyce, N. White, A. Macnish and D. Joyce. 2024. Internal disorders of mango fruit and their management- physiology, biochemistry, and role of mineral nutrients. Plants 13:2596.

Velderrain-Rodríguez, G.R., H. Torres-Moreno, M.A. Villegas-Ochoa, J.F. Ayala-Zavala, R.E. Robles-Zepeda, A. Wall-Medrano and G.A. González-Aguilar. 2018. Gallic acid content and an antioxidant mechanism are responsible for the antiproliferative activity of 'Ataulfo'mango peel on ls180 cells. Molecules 23:695.

Wall-Medrano, A., F.J. Olivas-Aguirre, J.F. Ayala-Zavala, J.A. Domínguez-Avila, G.A. Gonzalez-Aguilar, L.A. Herrera-Cazares and M. Gaytan-Martinez. 2020. Health benefits of mango by-products. Food wastes and by-products: Nutraceutical and Health Potential, pp.159-191.

Yu, M. and S. Watson. 2024. Market overview of health and wellness food products. In: *Flavor-associated applications in health and wellness food products.* Springer pp.3-19.